The structural, functional, and nutritional adaptation of college basketball players over a season

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The purpose of this study was to determine the structural, functional and nutritional adaptation of college basketball players over s season. Structure was determined by somatotype and body composition, function was determined by peak work capacity and work efficiency, and nutrition was determined by plasma metals analysis. The tests were performed twice on each of the eight subjects, one preseason (PRS) and one postseason (PST). A small structural adaptation was indicated by a mean decrease (<1 kg) in fat free weight and an increase in ectomorphy (<0.03). Body weight and skinfolds did not change significantly. Functional adaptation was indicated by a one minute decrease in running time for the work capacity test ($p<0.002$), and an increase ($p<0.02$) in $\dot{V}O_2$ for the work efficiency test. Nutritional adaptation was indicated by a greater mobilization of plasma Zn after exercise during PST than PRS. Plasma Cu apparently was mobilized during exercise in PST but the change during the season (-10 to -6.6%) was not statistically significant because of the large interindividual variability in response. Structural and functional adaptation to basketball training over a collegiate season is small; however, the change in Zn mobility and the tendency for a concomitant change in Cu mobilization offers a unique finding to help explain the nutritional adaptation to training.

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College basketball players undergo intense training on a daily basis during the season and participate regularly in basketball activities between seasons. We could infer that basketball players maintain their trained state not only during the season but between seasons as well. If this is true, basketball coaches could minimize training time for structural and functional conditioning and maximize training time for skill, tactics, and strategy practice.

Studies by Coleman *et al.*[1] and Campbell [2] with male college freshmen basketball players indicated no change in aerobic capacity over a season. Olds [3] reported similar results for high-school male basketball players. Sinning and Adrian [4] reported a significant increase in maximum oxygen consumption for female college basketball players over a season, but this result was not accompanied by concomitant increase in other related pulmonary and cardiovascular responses. McArdle *et al.*[5] reported no significant increase in maximum oxygen consumption for female college basketball players over a season. A tentative explanation for these observations may be that the basketball players, who were the subjects in these studies, began the season at a level of fitness equal to the structural and functional demands of playing basketball, and maintained rather than changed their level of fitness over a season.

These studies contributed significantly to the knowledge base of training studies. They deal principally with structural and functional adaptation, however, they do not include nutritional information. This study was planned to determine the structural, functional, and nutritional adapation of male college basketball players for a period of five months during a competitive season.

Method

Male basketball players who were recruited to play on the 1980-1981 University of North Dakota (UND) basketball team participated in this study that was approved by the Institutional Review Board of the University of North Dakota and the Human Studies Review Committee of the United States Department of Agriculture. The purpose and procedures for the study were explained to the players after which each player gave written consent. The tests were administered two times, one preseason (PRS) and one postseason (PST). The PRS test was administered before the start of formal basketball practice and the PST test was administered after the final game of the competitive season. Twelve players completed the PRS test and eight players completed the PST test. The tests included: anthropometry, the Bruce treadmill test, and pre and postexercise blood chemistry.

The anthropometric tests were administered according to the procedure identified by Heath and Carter [6] and Durnin and Rahaman.[7] Somatotype was estimated from the Heath and Carter [7] Anthropometric Somatotype Rating form. Body composition was computed using four skinfold thicknesses and the Durnin and Womersley [8] equation for predicting body density, and Siri's [9] equation for percent fat. All tests were administered by the principal investigator. Testor reliability has been previously established as r=0.95-1.00 for each of the anthropometric measurements.

The Holtain skinfold caliper. Harpenden anthropometer, Lufkin metal tape measure and Medico body weight scale were the test instruments. Each instrument was calibrated for zero and a range which included all maximum scores. The instruments were calibrated prior to each test administration.

The Bruce *et al.*[10] treadmill test was used to measure work, power, heart rate and the cardiorespiratory response by the players to volitional exhaustion. Heart rate and ECG were monitored continuously with a Quinton ECG Monitoring System (Model 621; Quinton Instruments Co, Seattle, WA, USA) using a bipolar CM_5 ECG lead.

Oxygen consumption ($\dot{V}O_2$) was measured using a Beckman metabolic measurement cart (MMC), as described by Wilmore,[11] at 60 second intervals for 5 minutes of preexercise and during each minute of exercise. The MMC volume measurement was calibrated by a syringe with a known volume. The oxygen and carbon dioxide analyzers of the MMC were calibrated by analysis of certified reference gases.

A sample of whole blood was obtained from an antecubital vein before and again after each treadmill test. Plasma metals and lactate were measured from each sample. Plasma copper (Cu), zinc (Zn), iron (Fe), and magnesium (Mg) were analyzed by the method of Parker *et al.*,[12] and lactate by the method of Henry.[13]

A repeated measures ANOVA [14] was used to identify significant changes in the data over the season. Only the data for those players who completed both tests (PRS and PST) were included in the analysis (N=8).

Results

Structural changes

The increase in the sum for four skinfolds plus the decrease in body weight combined to produce the significant

TABLE I.—*Changes in somatotype and body composition.*

Variable	Unit	Preseason		Postseason		p
		X̄	SD	X̄	SD	
Body composition						
Weight	kg	89.0	12.4	88.3	11.7	NS
Stature	cm	195.4	10.9	195.7	11.0	NS
Sum of 4 skinfolds	mm	19.5	3.0	20.4	2.7	NS
Density	$g \cdot cc^{-1}$	1.0817	0.0042	1.0804	0.0037	0.05
Fat weight	kg	6.9	2.3	7.3	2.1	NS
Fat free weight	kg	82.1	10.6	81.0	10.2	0.04
Somatotype						
Endomorphy	—	1.4	0.42	1.6	0.35	NS
Mesomorphy	—	3.4	1.19	3.2	1.33	NS
Ectomorphy	—	3.4	1.05	3.7	0.96	0.03

NS=p>0.05.

decrease in body density and fat free weight (Table I). These changes were very small, <1 kg in body weight and <1 mm in skinfold thickness. Considering that this accrued over five months, the changes apparently are of little consequence when explaining the effect of training over a season.

Changes in somatotype were small but tended to reflect the changes in body composition (Fig. 1).

The mean ectomorphic component rating increased significantly as a result of the decrease in body weight without a change in stature. The mean endomorphic and mesomorphic component ratings remained unchanged.

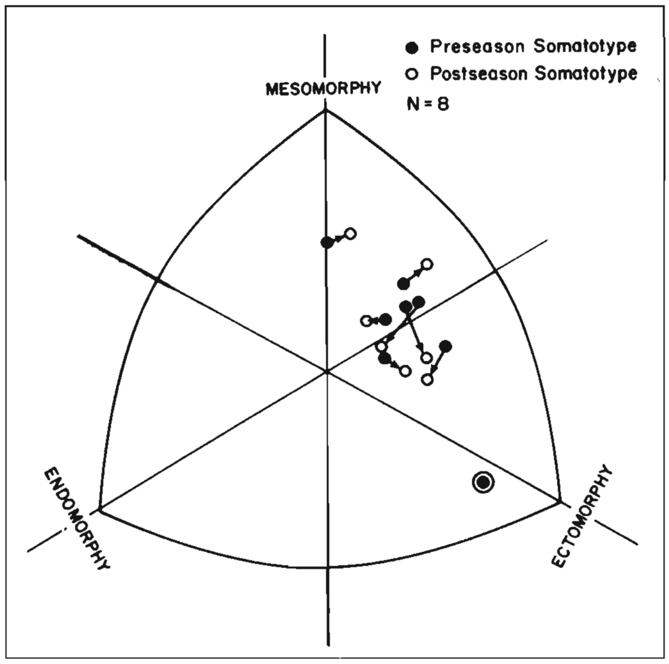

Fig. 1.—Changes in somatotype.

Functional changes

Mean time to exhaustion using the Bruce test decreased, ($p<0.05$) from 20.8 minutes (PRS) to 19.6 minutes (PST) (Table II). Because time is involved in the calculation of work, work decreased also ($p<0.05$).

The peak work capacity of the basketball players was unchanged over the season. Although oxygen consumption ($\dot{V}O_2$) increased, the change from PRS to PST season was only 1.6%. This value is less than the standard deviation for repeated determinations of 3%.[15]

The work efficiency of the basketball players was evaluated by a comparison between the PRS and PST metabolic response during the last minute of the last completed stage of the Bruce treadmill test (Table III). Comparisons were made at the same work, power, and time. Because work, power, and time remained the same, any change in metabolic response between PRS and PST was interpreted as a gain or loss in work efficiency. These comparisons produced nonsignificant differences for $\dot{V}O_2$ in $L \cdot min^{-1}$, 4519 ± 257

TABLE II.—*Changes in work capacity.*

Variable	Unit	Preseason $\bar{X}$	Preseason SD	Postseason $\bar{X}$	Postseason SD	p
Weight	kg	89.0	12.4	88.3	11.7	NS
Time	min	20.8	1.4	19.6	1.3	0.002
Power	watt	363	50.8	343	45.4	NS
Work	kilojoule	190	28.9	163	15.4	0.004
$\dot{V}_E$	$L \cdot min^{-1}$	149	8.5	142	9.3	NS
F	$breath \cdot min^{-1}$	40	4.8	39	6.4	NS
HR	$beat \cdot min^{-1}$	187	13.7	188	14.4	NS
$\dot{V}O_2$	$L \cdot min^{-1}$	4749	378	4825	511	NS
$\dot{V}O_2$	$ml\ (kg \cdot min)^{-1}$	53.8	4.5	55.0	4.9	NS
$\dot{V}CO_2$	$L \cdot min^{-1}$	5716	540	5342	379	0.03
RER	—	1.2	0.05	1.1	0.06	0.009
$\dot{V}_E/\dot{V}O_2$	—	29.6	3.6	31.5	1.9	NS
$\dot{V}_E/\dot{V}CO_2$	—	26.2	1.7	26.6	2.3	NS

V_E=expired volume; F=respiratory frequency; HR=heart rate; RER=respiratory equivalent ratio; NS=$p>0.05$.

TABLE III.—*Changes in work efficiency.*

Variable	Unit	Preseason $\bar{X}$	Preseason SD	Postseason $\bar{X}$	Postseason SD	p
Weight	kg	89.0	12.4	88.3	11.7	NS
Time	min	19.4	1.7	19.4	1.7	NS
Power	watt	321	42.3	318	38.9	NS
Work	kilojoule	158	23.5	157	22.9	NS
$\dot{V}_E$	$L \cdot min^{-1}$	131	11.0	138	10.8	0.02
F	$breath \cdot min^{-1}$	38	7.1	39	6.3	NS
HR	$beat \cdot min^{-1}$	180	14.9	184	15.0	NS
$\dot{V}O_2$	$L \cdot min^{-1}$	4519	257	4655	290	NS
$\dot{V}O_2$	$ml\ (kg \cdot min)^{-1}$	51.4	5.8	53.4	6.3	0.02
$\dot{V}CO_2$	$L \cdot min^{-1}$	5106	337	5185	207	NS
RER	—	1.1	0.06	1.1	0.05	NS
$\dot{V}_E/\dot{V}O_2$	—	29.1	2.9	29.8	3.3	NS
$\dot{V}_E/\dot{V}CO_2$	—	25.7	2.0	26.7	2.2	NS

NS=$p>0.05$.

in the PRS and 4655 ± 290 in the PST; however, $ml \cdot kg \cdot min^{-1}$ increased significantly ($p<0.02$). This significant increase was the result of a decrease in mean body weight from PRS to PST (89.0 ± 12.4 kg to 88.3 ± 11.7 kg).

Because neither the $\dot{V}O_2$ nor the $\dot{V}CO_2$ changed from PRS to PST, the significant increase in $\dot{V}E$ from 131 $L \cdot min^{-1}$ to 138 $L \cdot min^{-1}$, which is less than 5%, suggests that the change in $\dot{V}E$ is a respiratory measurement error rather than a metabolic change.

The PRS to PST changes of the other variables were not significant, indicating no change in work efficiency over the season.

Nutritional status

Preexercise values of hematocrit and plasma metal concentrations (Table IV) were within the range of normal values. The preexercise levels of some biochemical indices of nutritional status changed during the season. Only hematocrit, plasma Cu and plasma Zn increased ($p<0.05$).

Postexercise plasma Cu and plasma Zn

TABLE IV.—*Changes in preexercise blood chemistry.*

Variable	Unit	Preseason		Postseason		p
		X̄	SD	X̄	SD	
Hematocrit	Percent	44.2	1.3	46.0	1.7	0.007
Plasma Cu	$\mu g \cdot dl^{-1}$	76.2	10.8	88.6	14.7	0.04
Plasma Zn	$\mu g \cdot dl^{-1}$	72.5	11.4	102.5	10.1	0.0005
Plasma Fe	$\mu g \cdot dl^{-1}$	109.4	20.5	116.5	38.8	NS
Plasma Mg	$mg \cdot dl^{-1}$	1.8	0.24	1.7	0.09	NS
Lactate	$mM \cdot L^{-1}$	1.1	0.3	1.4	0.6	NS

NS = $p > 0.05$.

TABLE V.—*Changes in postexercise blood chemistry.*

Variable	Unit	Preseason		Postseason		p
		X̄	SD	X̄	SD	
Hematocrit	Percent	48.8	1.4	49.8	2.4	NS
Plasma Cu	$\mu g \cdot dl^{-1}$	80.5	10.2	94.5	16.7	0.02
Plasma Zn	$\mu g \cdot dl^{-1}$	76.6	11.2	115.6	16.8	0.001
Plasma Fe	$\mu g \cdot dl^{-1}$	127.0	30.5	132.0	42.0	NS
Plasma Mg	$mg \cdot dl^{-1}$	1.8	0.22	1.8	0.12	NS
Lactate	$mM \cdot L^{-1}$	8.1	1.8	7.0	1.4	NS

NS = $p > 0.05$.

TABLE VI.—*Van Beaumont quotient percent change after exercise from pre to postseason after exercise.*

Variable	Preseason		Postseason		p
	X̄	SD	X̄	SD	
Plasma volume	−16.5	2.6	−13.8	5.6	NS
Plasma Cu	−10.0	3.7	−6.6	7.8	NS
Plasma Zn	−10.0	4.2	−1.7	6.4	0.03
Plasma Fe	−0.6	22.2	−0.6	6.3	NS
Plasma Mg	−12.3	7.0	−11.8	6.6	NS
Lactate	579	232	457	348	NS

NS = $p > 0.05$.

also increased ($p < 0.02$) at the end of the season (Table V).

To interpret the change in plasma metal concentrations after exercise, it is necessary to take into consideration the effect of changes in hemoconcentration associated with alterations in hematocrit. This was done using the Van Beaumont *et al.*[16] quotient as described by Lukaski *et al.*[17] The exercise-induced changes in circulating plasma metals (Table VI) were not different during the season except for plasma Zn, which increased ($p \pm 0.03$).

Discussion

Structural changes

Small reductions in skinfold thickness appear to be characteristic of a training effect over a season. Green and Houston [18] reported small changes in anthropometric dimensions for male ice hockey play ers, and Hanson [19] reported similar results for the US nordic Ski team. Lundegren,[20] Wade,[21] Thompson,[22] and Thompson *et al.*[23] also reported decrease in skinfold measurements among female and male athletes over a season. Lundegren [20] studied female basketball and field hockey players; Wade [21] studied female swimmers and Thompson *et al.*[22] [23] studied male football, ice hockey, and basketball players.

The somatotype changes among the UND basketball players were different from those changes which occurred in football players over a UND football season.[24] The mean endomorphic component rating decreased, the mean mesomorphic component increased, and the mean ectomorphic component rating increased among the football players. These somatotype changes also reflected the changes in body composition.[24]

Functional changes

Although improvement in work capacity and efficiency may be expected over a season, this response does not appear to be consistent with the results reported in the literature for college athletes. McArdle *et al.*[5] with female basketball players, Green and Houston [18] with male ice hockey players, and Hanson [19] with skiers, reported a lack of improvement in peak $\dot{V}O_2$ over the season. Even the significant increase in peak oxygen consumption for female college basketball players reported by Sinning and Adrian [4] lacked concomitant improvement in related pulmonary and cardiovascular measurements.

The amount of structural and functional change over a season may be the result of entry level performance. Wilmore [25] reported significant increases in strength and lean body weight, with concomitant decrease in fat as a result of participation in a 10 week weight training program. Boileau *et al.*[26] and Moody *et al.*[27] reported similar compositional results for adult men and high school girls, respectively. These studies indicate significant changes in body composition among participants who were relatively untrained.

Athletes who train between, as well as during, the sport season may reduce their structural and functional trainability by virtue of their high entry level performance. Glick and Kaufman [28] demonstrated that body weight and skinfold change were related to entry level during training. Those subjects who had the largest skinfold thickness, reduced body weight and skinfold thickness; subjects with the smallest skinfold thickness, gained body weight and skinfold thickness; and subjects with medium skinfold thickness gained body weight and reduced skinfold thickness.

Coaches generally prescribe exercise for warm-up or maximum performance. The goal that motivates this prescription is the desire to improve performance. However, maintaining maximum performance does not require maximum intensity exercise prescription. Lukaski and Bolonchuk [29] have reported maintaining maximum aerobic capacity and body composition of groups of male volunteers over 3 months and 6 months with a submaximum exercise prescription. Exercise for these subjects was prescribed based on the American College of Sports Medicine [30] guidelines. Subjects performed 3 $d \cdot wk^{-1}$ at 50% of maximum power for 15 minutes, over periods ranging from 3-9 months. This prescription of exercise maintained body composition and work capacity at the entry level.

Nutritional changes

The significant changes in preexercise plasma Zn ($p<0.0005$) and Cu ($p<0.04$) indicate improvement in nutritional status during the season. This observation is enhanced by examining the postexercise changes in these trace element levels.

The observed postexercise changes in

plasma trace element concentrations may provide some insight about the influence of physical training on nutritional status. The Van Beaumont quotient, which is an index of the change in circulating plasma constituent after exercise relative to the change in plasma volume, has been related to changes in whole body retention of trace elements.[17] Briefly, if the calculated Van Beaumont quotient for a plasma constituent are of the same direction (*e.g.*, sign) and magnitude as the estimated change in plasma volume, then that component is considered to be taken up or removed from the circulation during exercise. However, if the Van Beaumont quotient is of opposite sign as that of the plasma volume change, then that constituent is being added to the blood.

In the present study, plasma volume decreased 16.5 and 13.8% after exercise during PRS and PST, respectively. A significant ($p<0.03$) change in the Van Beaumont quotient for plasma Zn from PRS (-10%) to PST (-1.7%) indicated a greater mobilization of Zn after exercise. Copper apparently also was mobilized during exercise in PST, but the change during the season (-10 to -6.6%) was not statistically significant ($p>0.05$) because of the large interindividual variability in response. The relative changes in plasma Fe and Mg are of the same direction and similar magnitude as the plasma volume decrease, which suggests that these elements probably exit the vascular space. In contrast, the Van Beaumont quotient for lactate is opposite in sign and markedly greater than the change in plasma volume. This indicates an accumulation of lactate in the blood because of incrased metabolic production and inadequate disposal of lactic acid during maximal progressive exercise.[17] Thus, these data suggest a unique adaptation of trace element metabolism during physical training.

Conclusions

Structural and functional adaptation to basketball training over a season appears to be similar to those changes cited in other training studies, that is, either small or not significant. The change in Zn mobilization and a tendency for concomitant change in Cu mobilization, however, offers a unique finding to explain the nutritional adaptation to training.

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